1914.

(38) 19

No

KSC-SPEC-Z-0016
2 June 1969

JOHN F. KENNEDY SPACE CENTER, NASA

AUTOMATIC WELDING, STAINLESS STEEL PIPE & TUBING, INVAR 36 PIPE, CARBON STEEL PIPE, ALUMINUM PIPE SPECIFICATION FOR

DESIGN ENGINEERING DIRECTORATE

APPROVED:

G. MERRITT PRESTON
DIRECTOR OF DESIGN ENGINEERING

KSC-SPEC-Z-0016
2 June 1969

JOHN F. KENNEDY SPACE CENTER, NASA

AUTOMATIC WELDING, STAINLESS STEEL PIPE & TUBING, INVAR 36 PIPE, CARBON STEEL PIPE, ALUMINUM PIPE

SPECIFICATION FOR

1. SCOPE

1.1 This specification covers automatic welding, inspection of welded joints, and qualification of welding operators and welding procedures for stainless steel pipe and tubing, Invar 36 pipe, carbon steel pipe, aluminum alloy pipe in critical launch support equipment. Automatic, pulsating-arc, tungsten, inert gas, welding process is applicable to this specification.

2. APPLICABLE DOCUMENTS

2.1 The following documents of the issue in effect on the date of issue of invitation for bids or requests for proposal form a part of this specification.

SPECIFICATION

Federal

QQ-R-566	Rods, Welding, Aluminum and Aluminum Alloys

Military

MIL-A-18455	Argon, Technical
MIL-E-21562	Electrode and Rods, Welding, Bare Nickel Alloy
MIL-E-23765/1B	Electrodes and Rods Welding, Bare, Solid Mild Steel
MIL-I-6866	Penetrant Method of Inspection
MIL-I-23413	Inserts, Welding Coiled, Filler Material, Solid Ring
MIL-I-25135	Inspection Materials, Penetrant

MIL-P-27407	Propellant Pressurizing Agent, Helium
MIL-R-5031B	Rod and Wire, Welding, Corrosion and Heat Resistant Alloys
MIL-T-8808	Tubing, Steel, Corrosion Resistant (18-8) Stabilized

John F. Kennedy Space Center

KSC-SPEC-Z-0001	Pipe, 36 percent Nickel, Iron Base (Invar 36), Specification For
KSC-SPEC-Z-0002	Welding, Aluminum Alloy Pipe, Tubing and Associated Fittings, Specification For
KSC-SPEC-Z-0003	Welding, Stainless Steel and Invar 36 Pipe, Tubing and Associated Fittings, Specification For
KSC-SPEC-Z-0007A	Tubing Steel, Corrosion Resistant Types 304 and 316 Seamless, Annealed, Specification For
KSC-SPEC-Z-0012	Ultrasonic Testing, Specification For
KSC-SPEC-Z-0014	Recording of Radiographic Reports of New Critical Weldments, Brazements, Castings, Forgings, Expansion Joints, and Flex Hoses, Specification For

STANDARDS

Military

MIL-STD-271	Non-destructive Testing Requirements for Metals
MIL-STD-453	Inspection, Radiographic
MIL-STD-410A	Qualification of Inspection Personnel (Magnetic Particle and Penetrant)

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

2.2 Other Publications.- The following documents form a part of this specification to the extent specified herein. Unless otherwise indicated, the issue in effect on the date of issue of invitation for bids or requests for proposals shall apply.

John F. Kennedy Space Center

GP-630	Manual for Operation of Automatic Pipe Welding Machine

American Society of Mechanical Engineers

ASME Boiler and Pressure Vessel Code, Sections VIII and IX

(Application for copies should be addressed to the ASME Order Department, United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.)

American Society for Testing and Materials (ASTM)

A106	Seamless Carbon Steel Pipe for High Temperature Service
A312	Specification for Seamless and Welded Austenitic Stainless Steel Pipe
A559	Mild Steel Electrode for Gas Metal Arc Welding
B241	Aluminum Alloy Seamless and Extruded Pipe
B285	Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes
B297	Specification for Tungsten Arc-Welding Electrodes

(Application for copies should be addressed to The American Society for Testing and Materials, 1916 Race Street, Philadelphia, Penna. 19103.)

American Welding Society

AWS A2.0	Standard Welding Symbols
AWS A2.2	Nondestructive Testing Symbols
AWS A3.0	AWS Definitions - Welding and Cutting
AWS A5.10	Aluminum and Aluminum Alloy Welding Rods and Bare Electrodes

(Application for copies should be addressed to the American Welding Society, Inc., United Engineering Center, 345 East 47th Street, New York, N. Y. 10017.)

3. REQUIREMENTS

3.1 General.- Welds shall not exceed the allowable defect limits contained within Table I.

3.2 Materials.

3.2.1 Base Metals.

3.2.1.1 Stainless Steel.- Stainless steel shall be annealed, Type 304, 304L, 316, 316L, 321, 347, or 348, conforming to the requirements of ASTM A312, MIL-T-8808, and KSC-SPEC-Z-0007A.

3.2.1.2 Invar 36.- Material shall be Invar 36 and conform to the requirements of KSC-SPEC-Z-0001.

3.2.1.3 Carbon Steel.- Carbon steel shall conform to ASTM A106, Grade B.

3.2.1.4 Aluminum Alloy.- Aluminum alloys shall be 3003 and 6061 T6 and conform to ASTM B241.

3.2.2 Filler Metal.

3.2.2.1 Procurement.- Filler metal shall conform to Tables II, III, IV and V and in compliance with MIL-R-5031B, MIL-E-21562, QQ-R-566, MIL-E-23765/1B, ASTM B285, and ASTM A559, as applicable.

3.2.2.2 Analysis.- Mill certification of analysis shall be required for modified Invar 36 filler metal in compliance with Table III.

3.2.2.3 Storage.- Filler metals shall be stored in such manner as to prevent moisture contact and condensation, and shall be handled in a manner to avoid damage to the surface.

3.2.2.4 Tungsten Electrodes.- Tungsten electrodes shall be 2% thoriated and conform to ASTM B297.

3.2.3 Shielding Gases.- Only argon or helium gas or these gases in combination shall be used as applicable to stainless steel, Invar 36, carbon steel, and aluminum pipe welding.

3.2.3.1 Argon Gas.- Argon gas shall conform to MIL-A-18455.

3.2.3.2 Helium Gas.- Helium gas shall conform to MIL-P-27407.

3.2.4 Consumable Inserts.- Consumable inserts (Class 4 Y-shape and Class 1 Inverted T-shape or equivalent) may be used for the root pass of stainless steel, carbon steel and Invar 36 pipe in sizes over 1 inch diameter or wall thickness over 0.065 inch. Insert material shall be the same as filler materials in Tables II, III, and IV, and conform to MIL-I-23413.

3.3 Welding Process.- Welding shall be made by automatic, pulsating-arc tungsten inert gas welding process.

3.3.1 Root Pass.- Whenever possible, both surfaces of the root pass shall be visually inspected and shall be free of defects, prior to welding subsequent passes.

3.3.2 Joint Preparation and Fit-Up.

3.3.2.1 Joint Design.- The details of the pipe joint design shall be in accordance with the qualified welding procedure (see 4.3) and the engineering drawings.

3.3.2.2 Joint Ends.- Joint ends shall be prepared to provide a smooth uniform surface. Flame cutting shall not be used on stainless steel, Invar 36 or aluminum material.

3.3.2.3 Pipe and Tubing Alignment.- The alignment of abutting ends shall be regulated to minimize offset between surfaces. (See Table I.)

3.3.2.4 Lineup Clamps.- Either internal or external lineup clamps may be used. The clamps may be removed when sufficient welding has been performed to prevent movement of the pipe.

3.3.2.5 Tack Welds.- Tack welds may be made by manual TIG method or automatic process.

3.3.3 Restrictions.

3.3.3.1 Heating.- Preheating or postheating is not permissible in welding stainless steel and Invar 36 pipe and tubing. Preheating of aluminum pipe and tubing shall provide a maximum of 325°F for heat-treatable alloys. For non-heat-treatable alloys, a temperature range of 200° to 500°F shall be used as required to make sound welds. The maximum interpass temperature for stainless steel shall be 250°F maximum.

3.3.3.2 Peening.- Peening is not permitted.

Table I. Allowable Defect Limits

DEFECT	ALLOWABLE DEFECT LIMITS
Cracks	None
Mismatch	Less than 0.050 inch - one wall thickness 0.050 to 0.109 inch 1/2 wall thickness Greater than 0.109 inch - 1/3 wall thickness
Porosity open to surface	None in stainless, 3 per inch. 1/ Aluminum and carbon steel
Undercut	10% T or 0.03 inch whichever is less 1T maximum length in any 10T length of weld
Incomplete Penetration	None
Craters	None
Underbead drop-through	50% T but not to exceed 1/8 inch I.D. shall not be reduced more than 20%
Thinning	Not less than minimum T
Sub-surface Defects	See Porosity Charts, Figure 1 for stainless steel, Figure 2 aluminum, and ASME Section VIII carbon steel
Lack of Fusion	None
Burn through	None
Notches	None
Scratches and Gouges	12-1/2% of wall thickness

1/ Maximum size 30 percent of T or 0.10 inch, whichever is the lesser

Table II. Stainless Steel Filler Metal

Base Metal	Bare Wire Filler Metal
304	ER 308 1/
304L	ER 308L 1/
316	ER 316 1/
316L	ER 316L 1/
321	ER 347 1/
347	ER 347 1/
348	ER 347 1/
Invar 36 to Stainless	INCO 82 2/

1/ MIL-R-5031B
2/ MIL-E-21562 Type EN 82

Table III. Modified Invar 36 Filler Metal for Welding Invar to Invar

Element	Percent
Nickel	35.0 - 37.0
Manganese	2.5 to 3.0
Titanium	0.8 to 1.2
Carbon	0.10 (max)
Silicon	0.10 (max)
Sulphur	0.01 (max) 1/
Phosphorus	0.02 (max) 1/
Iron	Remainder

1/ Sulfur and phosphorus content shall be kept as low as possible. Their sum shall not exceed 0.025 percent.

Table IV. Aluminum Alloy Filler Metal

Base Metal	Bare Wire Filler Metal
3003	ER 1100 1/
6061 T6	ER 5356 1/

1/ QQ-R-566 & AWS A5.10

Table V. Carbon Steel Filler

Base Metal	Bare Wire Filler Metal
A106 Grade B	E70 S-2 1/ E60 S-2 1/

1/ per MIL-E-23765/1B and ASTM A559

3.3.3.3 Stamping.- Critical launch support piping and tubing shall not be metal stamped.

3.3.3.4 Invar Filler Metal.- When welding Invar 36, all root passes shall require addition of filler metal.

3.3.4 Cleaning.-

3.3.4.1 Preweld Cleaning.- The weld preparation and adjacent base metal surface (for a minimum of 1 inch on each side of the weld preparation) shall be cleaned prior to welding. Surfaces shall be free of scale, slage, oil, grease, paint, pencil or ink marks, oxides, and other impurities. All burrs shall be removed from the joint. Solvent cleaning shall be used. Fixtures and insert rings, used in the vicinity of the weld, shall be cleaned of any foreign matter that may contaminate the weld. All cleaning shall be done before assembling the joints. Solvents shall not be used after the joint is assembled.

3.3.4.2 Interpass Cleaning.- When multiple-pass welding is used, contaminants left upon completion of a pass shall be removed before depositing the next pass.

3.3.4.3 Postweld Cleaning.- Promptly after welding, the joint shall be brushed to remove contaminants. Only clean, austenitic stainless steel wire brushes that have not been used on other types of material shall be used.

3.3.5 Workmanship.- Weld deposits, buildup, and drop-through shall have a smooth appearance or an even repetitive ripple. The base material shall be free of scratches or gouges. (Ref. Table I.) The completed weld shall have a substantially uniform cross section around the entire circumference of the pipe. At no point shall the weld reinforcement surface be below the surface of the pipe, nor shall the maximum weld reinforcement exceed 1/8 inch. Butt welds shall have 100 percent joint penetration. Mechanical profiling may be used to bring reinforcement within allowable limits. A smooth transition suck back of no greater than 10% of wall thickness is permitted, when evaluated by visual means.

3.3.6 Protection from Environment.- Protection, such as portable wooden frames, plastic, or canvas structures, shall be provided by the contractor to protect field welding areas from weather conditions including, but not limited to, airborne moisture, blowing sand, and winds.

3.3.7 Welding Positions.- Welding may be performed in the qualified horizontal and vertical fixed positions.

3.4 Qualification.

3.4.1 Procedure Qualification.- Prior to starting production welding under this specification, a joint welding procedure shall be established and qualified to demonstrate that welds having suitable mechanical properties and soundness, can be made. Procedure qualification shall be conducted as specified in 4.3 of this specification.

3.4.2 Performance Qualification.- Prior to performing welding under this specification, welding operators shall be qualified as specified in 4.4 of this specification.

3.5 Nondestructive Testing and Inspection.

3.5.1 Visual Inspection.- All piping welds shall be visually inspected for compliance with the applicable welding procedures, drawings, and this specification. Visual inspection shall be performed without the aid of magnifying devices, unless otherwise specified. Visual inspection shall be performed at the following stages, and including at least the following items:

a. Prior to welding for:

(1) Weld-end preparation, dimensions and finish
(2) Clearance dimensions of consumable inserts, when applicable
(3) Alignment and fit-up of the pieces being welded
(4) Verification of cleanliness requirements

b. After each pass of multiple-pass welding for:

(1) Proper cleaning, fusion and contour
(2) Removal of any defect found

c. After welding for:

(1) Contour and finish of outside surface of weld, and inside surface, where possible
(2) Degree of undercutting
(3) Evidence of mishandling, excessive impression marking or excessive grinding
(4) Signs of imperfect or incomplete fusion

3.5.2 Radiographic Inspection.- Radiographic inspection (100 percent) shall be accomplished as soon as possible after completion of all butt welds, as follows:

3.5.2.1 Radiographic Inspection Procedure.- Radiographic inspection shall conform to MIL-STD-453 with the following exception: Penetrameters for use with radioactive isotopes shall conform to the requirements of the ASME Boiler and Pressure Vessel Code, Section VIII, Paragraph UW-51.

3.5.2.2 Safety Film.- Extra fine grain safety film shall be used for all radioactive isotope radiography and for X-ray radiography when the material thickness is less than 1/4 inch. For X-ray radiography of material 1/4 inch thick or thicker, extra fine grain safety film or fine grain safety film shall be used.

3.5.2.3 Film Viewing.- Superimposed film viewing shall not be used except following written request to, and written approval of, the procuring activity. For double wall radiographs, the beam shall be offset 20^{o} from the plane passing through the weld to prevent superimposed weld images. Single wall radiography shall be used whenever size and accessibility permit.

3.5.3 Ultrasonic Inspection.- Ultrasonic inspection may be used at the option of the contractor and with the approval of the procuring activity. Procedures and equipment utilized are subject to approval by the procuring activity. (Reference KSC-SPEC-Z-0012 - Ultrasonic Testing, Specification For.)

3.5.4 Liquid Penetrant Inspection.- When specified, liquid penetrant inspection shall be performed as specified in MIL-STD 410A, and as follows:

3.5.4.1 Liquid Penetrant Inspection Procedure.-Inspection shall be performed in accordance with MIL-I-6866. Acceptance shall be in compliance with paragraph 4.2.3.

3.5.4.2 Type of Penetrant.- Non-water washable dye penetrant conforming to MIL-I-25135 (Group I penetrant) shall be used.

3.5.4.3 Inspection Record.- The liquid penetrant inspection shall include a record of the following:

a. Brand name and specific type of penetrant, penetrant remover, and developer

b. Details of the pretest cleaning method, cleaning materials, and drying time

c. Method of penetrant application including time it remains on the surface

d. Method of removing penetrant and drying the surface before applying developer

e. Method of applying the developer and length of developing time before inspection

f. Method of post-test cleaning

g. Defects and their locations

3.5.5 Additional Inspection.- Additional inspection, by any applicable method, shall be performed when the weld quality is questionable, when directed by the procuring activity's technical representative. The procuring activity reserves the right to remove up to 1 percent of all finished production welds for destructive testing.

3.6 Repair of Weld Defects.- Welds not meeting the requirements of this specification shall be rejected. Rejected welds shall be repaired and re-inspected for conformance with the requirements specified herein. Not more than three repairs shall be allowed in a single weld seam. The size of a single repair weld shall not exceed six times the wall thickness in width or one pipe diameter in length. Repairs may be made by manual TIG process in compliance with KSC-SPEC-Z-0002 or KSC-SPEC-Z-0003 as applicable. Manual process may be used for carbon steel in compliance with the ASME Boiler and Pressure Vessel Code, Sections VIII and IX.

3.6.1 Special Approval.- Prior to performing repair welding, the following types of weld repairs shall require specific approval of the NASA procuring activity:

a. Repair of base material defects

b. Repair of welds after the second cycle of repair

c. Repair following hydrostatic test

3.6.2 Repair Procedure Approval.- Prior to performing welding repairs that require specific approval, a repair procedure specification shall be submitted for approval. The repair procedure shall include as a minimum:

a. A description of the defect to be repaired

b. Method to prevent contamination of piping, component, or system

c. Method of defect removal

d. Inspection procedure to insure removal of defect

e. Essential elements of the repair welding procedure

f. Inspection procedure following completion of repair

3.6.3 Records of Weld Repair.- Records shall be maintained on any repair of welds covered by 3.6. This record shall be included in the weld joint inspection record and shall include at least the following information:

a. Location of defect by sketch or marked drawing or reference to film marker position numbers

b. Description of defect, including type (slag, porosity, crack, etc.), size and maximum depth

c. Reference to approved repair welding procedure (if required)

d. Inspection procedures before and after repair and results thereof

e. Identification of repair welders

3.7 Marking of Welds.

3.7.1 Identification and Records.- Positive identification of welds and positive records of the inspection status of a particular weld joint shall be maintained during all operations.

3.7.2 Welder Identification.- Using welding operators personal stamp, each welded assembly shall be marked by the contractor to identify the assembly with the welding operator who made the welds.

3.7.3 Type of Markings.- Unless otherwise approved by the procuring activity, weld identification shall be permanent markings, which are intended for permanent identification, and may be made by vibrating marking tools or electrochemical etching.

3.7.4 Acceptable Welds.- Welds meeting the requirements of this specification shall, after being approved by the Government inspector, be painted using a stencil of the approved symbol.

3.8 Records.- Complete records of all inspections and tests shall be maintained and shall be available to the authorized Government personnel. Identification shall meet the requirements of KSC-SPEC-Z-0014.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Requirements.- The contractor is responsible for the performance of all inspection requirements as specified herein. Except as otherwise specified, the contractor may utilize his own or any other inspection facilities and services acceptable to the procuring activity. Inspection and test records shall be kept complete and, upon request, made available to the procuring activity or its designated representative. The procuring activity or its designated representative, reserves the right to perform any or all of the inspections set forth in this specification to assure that the end item conforms to the prescribed requirements.

4.1.1 Reports.- Certification is required for each shipment of material furnished to this specification. Each certification shall contain results of chemical analyses, mechanical tests, and other inspections and tests required by this specification, and shall be identified with the material offered for acceptance. Qualification records for all welding procedures and welding operators shall be included. It shall be signed by an authorized representative of the contractor. Material certification is not required of Government furnished material where previous certification is available.

4.2 Test Procedures and Acceptance Criteria.

4.2.1 General Requirements.- Welds shall meet the quality requirements of this specification and the appropriate drawings including the following specified requirements:

a. Dimension

b. Surface finish

c. Freedom from defects such as porosity, inclusions, etc., in excess of the allowable defect limits of Table I, Section 3.

4.2.1.1 Inspection Record.- An inspection record for each weld joint shall be prepared. Figure 3 shows a sample record sheet; the tabulated information represents minimum requirements.

4.2.2 Radiographic Inspection Acceptance Criteria.- All welds shall meet the requirements of 4.2.1 and in addition shall be free of:

a. Clump porosity exceeding 1-1/2 times the diameter of a single "large" porosity spot. (A "clump" is defined as a group of holes in very close proximity forming a near-circular area in which the void area is 15 percent or more of the total area.)

b. Any 6-inch length of weld containing more than four clumps, or more than two clumps spaced less than 1/2 inch apart.

4.2.3 Liquid Penetrant Inspection Acceptance Criteria.- All surfaces shall be free of cracks. Indications as above and in crater area shall be removed and actual nature of defect determined by visual inspection; magnification up to ten times may be used to aid in evaluation. Indications evaluated as cracks, lack of fusion, lack of penetration, or porosity open to the surface are cause for rejection. If evaluation of a defect is difficult, grinding shall be performed to enable a true interpretation. When welding carbon or aluminum, surface indications identified as fine porosity less than 1/64 inch in largest dimension shall not be cause for rejection.

4.2.4 Ultrasonic Inspection.- This inspection may be used if other inspection methods are not sufficiently definitive, or at the request of the procuring activity. Inspection technique shall conform to accepted practice as defined in Section 7.5 of MIL-STD-271 and KSC-SPEC-Z-0012. All welds shall meet the requirements of 4.2.1.1.

4.2.5 Base Material Defects.- Base material defects detected during weld inspection shall be evaluated in accordance with the applicable material specification. If the base material specification contains no acceptance standards for the defects detected, the acceptance standards for the weld shall apply.

4.3 Welding Procedure Qualification Requirements.

4.3.1 General.- Before any production welding is performed, each welding procedure to be used in production shall be qualified as follows:

a. Record all the essential elements of the proposed welding procedure in a welding procedure specification. Figures 4 and 5 show a sample form.

b. Verify the proposed welding procedure by welding test joints and performing tests on the test joints in accordance with this specification.

c. Submit for approval the welding procedure specification, and a certified copy of the detailed results obtained from the tests performed on the test assemblies. When radiography is required, film and reports shall also be submitted. Submittals shall be made to the procuring activity.

4.3.2 Welding Procedure Specification Requirements.- The welding procedure specification shall include all essential elements of the welding procedure. The following as a minimum shall be included in sufficient detail to assure compliance with the requirement of the specification. (See Figure 4 for details.)

a. Base Metal

b. Filler Metal

c. Inert Gas

d. Positions

e. Heating

f. Drying of Electrodes

g. Consumable insert

h. Base metal thickness

i. Carriage size

j. Preparation of base material

k. Joint welding procedure

4.3.3 Records.- All qualified pipe-joint welding procedures shall be recorded in detail and shall be adhered to during subsequent construction except when a change is specifically authorized by the procuring activity.

4.3.4 Changes Requiring Requalification.- A change in any of the following essential variables shall require requalification as a new procedure specification.

4.3.4.1 Base Material

a. A change from one base material group to another. Groups shall be defined as follows:

Group 1 - Stainless
Group 2 - Invar 36
Group 3 - Carbon steel
Group 4 - 6061 T6
Group 5 - 3003

b. Changes in pipe size and schedule (change of 20% of tubing nominal diameter and wall thickness) shall require the welding procedure to be requalified.

c. Dissimilar metal welding shall require requalification.

4.3.4.2 Joint Design.

a. The addition, or deletion of an insert

b. A change in joint design shall require requalification

4.3.4.3 Filler Metal.

a. A change in series of filler metal. A change from one 300 Series stainless filler metal to another shall not require requalification.

4.3.4.5 Shielding Gas.- A change from one inert gas to another or the deletion or addition of a gas.

4.3.4.6 Welding Position.- A change from the horizontal to vertical position.

4.3.5 Weld Procedure Verification Tests.- The proposed welding procedure shall be qualified by welding test joints in accordance with the welding procedure specification and performing the required nondestructive tests. The nondestructive tests shall be performed as required for the production welds. In addition, destructive tests shall be performed in accordance with the requirements of this section on test specimens removed from the test joints. When there exists a previous qualified procedure for the applicable material group and carriage size, destructive testing shall not be required for change in nominal wall thickness diameters or pipe size.

4.3.5.1 General Requirements.- Records of the procedure verification tests shall include the actual materials and welding conditions used and test results obtained. Figure 5 shows a recommended form for recording this information.

4.3.5.1.1 Base Material Composition.- Base materials used shall be procured to the specifications referenced in the welding procedure specification, or shall be materials with equivalent chemistry, heat treatment, and condition; procured to alternate military or commercial specifications. Valid certification of material used must be available.

4.3.5.1.2 Test Joint Size.- The size of each test joint shall be sufficient to permit removal of the required test specimens, or duplicate test joints may be welded to provide sufficient material.

4.3.5.2 Nondestructive Tests.

4.3.5.2.1 Visual Inspection of Test Specimens.- Butt weld test specimens shall be visually inspected for defects.

4.3.5.2.2 Radiographic and Liquid Penetrant Inspection.- These tests shall be performed prior to sectioning the weld joint for destructive tests. The radiographic technique shall duplicate the procedure and test setup to be used in production radiography; evaluation shall be to the production welding standards. Failure to meet the radiographic test requirements shall constitute disqualification.

4.3.5.3 Destructive Tests.

4.3.5.3.1 Test Specimens.- Destructive test specimens shall be removed as shown in Figure 6 and shall be prepared for testing as shown in Figures 7 and 8. Two tensile, two root-bend specimens, and two face-bend specimens shall be removed. Applicable paragraphs of ASME Section IX shall apply where test specimens cannot be prepared in accordance with Figures 7 and 8.

4.3.5.3.2 Tensile Test.- Tensile specimens from pipe welds shall be ruptured under tensile load. The tensile strength shall be computed by dividing the maximum load at failure by the smallest cross-section area of the specimen as measured before the load is applied.

4.3.5.3.3 Bend Test.- Face-bend and root-bend specimens from pipe welds shall be bent in a guided bend test jig having the dimensions shown in Figure 9. Each specimen shall be placed on the die with the weld at mid-span. Face-bend specimens shall be placed with the face of the weld directed toward the gap. Root-Bend specimens shall be placed with the root of the weld directed toward the gap. The plunger of the jig shall be forced into the gap until the curvature of the specimen is approximately U-shaped with the weld centerline at the trough of the U. The bend test shall be considered acceptable if no crack or other defect exceeding 1/16 inch in any direction is present in the weld metal or the interface between the weld metal and the pipe material. Each specimen subjected to the bend test shall meet the above requirements.

4.3.5.3.4 Minimum Tensile Requirements.- The minimum tensile and yield strength and elongation shall be as shown in Table VI.

Table VI. Minimum Tensile Requirements

Tensile	Tensile Strength (p.s.i.) (min)	Yield Strength (p.s.i.) (min)	Elongation in 2 inches (%) (min)
304, 316	75,000	30,000	30
304L, 316L	70,000	25,000	25
Invar 36 to Invar 36	60,000	36,000	15
Invar 36 to 304 or 316	60,000	30,000	15
Invar 36 to 304L or 316L	60,000	25,000	15
Alloy 3003	14,000	--	--
Alloy 6061	22,000	--	--
ASTM A-106, Grade B	60,000	35,000	30

4.3.5.4 Retests.- If a weld procedure qualification test joint fails to meet the requirements, the procedure may still be qualified by welding and testing a new test joint for each test failed.

4.4 Performance Qualification of Welding Operators.

4.4.1 General Requirements.- Before any welding is performed on products covered by this specification, the contractor shall establish that each welding operator to be employed for such welding has been qualified by demonstrating his ability to make sound welded joints in accordance with previously qualified welding procedure specifications. Qualification tests shall be conducted in the presence of a duly authorized NASA quality representative. A welding operator who has made an original procedure qualification test is automatically qualified for the welding procedure used. Qualifications shall be established by:

a. Insuring that each welding operator has welded performance qualification test joints as specified herein and in accordance with the applicable qualified welding procedure specification.

b. Inspecting each performance qualification test joint in accordance with the requirements herein.

c. Evaluating the results of the nondestructive tests specified.

d. Recording the results of the tests and evaluation and the procedure specification. The recommended format for this record is shown in Figure 5.

e. Maintaining records of each welding operator and the extent of his qualification.

4.4.2 Performance Qualification Test.- The welding operator shall demonstrate his ability to make acceptable welds by welding performance qualification joints in accordance with the welding procedure specification. The qualification test records shall include the actual materials, welding conditions, and results obtained.

4.4.2.1 Welding Operators.

a. There shall be no repair welding on performance test joints except that which is found by the welding operator and repaired by himself in the normal course of welding.

b. Radiography shall be performed of test joints, using a single wall technique whenever possible, even though production welding will use a double wall technique.

c. Malfunction of equipment shall not be cause for penalizing welding operators. The welding operator shall be permitted to perform testing as an original test in the event equipment malfunctions.

4.4.2.2 Retests.- A welding operator failing to meet the test requirements may be allowed to retest as follows:

a. One immediate retest may be made that shall consist of two qualification test joints of each type failed, both of which shall meet all the applicable requirements, or,

b. A second retest may be allowed only after a further minimum of 16 hours of added training or practice. In this case, one test joint shall be made for each type failed.

4.4.3 Renewal of Qualification.- Renewal of qualification of a welding operator is required when the welder has not performed production welds that meet the requirements of this specification, for a period of 6 months or more. Such requalification shall consist of welding the specified qualification test joint using the welding process and filler metal used during the original qualification.

4.4.4 Requalification.- A welding operator must be requalified when the production welding procedure is changed in any of the essential variables listed below. Changes other than those listed do not require requalification. Changes requiring requalification are:

4.4.4.1 Base Material.

a. A change in base material group to any other base material group.

b. A change from a similar to a dissimilar metal weld or vice versa.

c. A change in automatic welding carriage size.

d. A change of 20% in nominal diameter and wall thickness of tubing used in actual line construction.

4.4.4.2 Joint Design.- A change in type of joint design or the deletion or addition of inserts.

4.4.5 Welding Position.- A change from horizontal to vertical or vertical to horizontal.

5. PREPARATION FOR DELIVERY

5.1 Where applicable, preparation for delivery shall be in accordance with the procurement documents.

6. NOTES

6.1 Intended Use.- This specification is intended for use in automatic welding stainless steel pipe and tubing, Invar 36 pipe, carbon steel pipe, aluminum pipe, carbon steel pipe for space vehicle ground support and launch operation equipment.

6.2 Waivers.- Approval of waivers to this specification shall be requested in writing, and the waivers shall be considered approved only when granted in writing by the procuring activity.

6.3 Drawings.- Welding symbols shall comply with AWS A2.0 Nondestructive testing symbols shall comply with AWS A2.2.

6.4 Nomenclature and Definitions.- Welding terms and definitions used in the preparation of drawings, specifications, and correspondence shall comply with AWS A3.0.

6.5 Data Required on Drawings or Procurement Documents.- The following information shall be provided on the engineering drawings or the procurement documents:

a. Title, number and date of this specification

b. Delivery preparation requirements

c. Exceptions to or exclusions from the requirements of this specification

6.6 Equipment Guideline.- KSC GP-630 may be used as an operational and procedure guideline.

Notice.- When KSC or Government drawings, specification, or other data are used for any purpose other than in connection with a definitely related KSC procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that KSC may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder to manufacture, use, or sell any patented invention that may in any way be related thereto.

Custodian:

NASA - John F. Kennedy Space Center
Kennedy Space Center, Florida 32899

Preparing activity:

John F. Kennedy Space Center
Mechanical Systems Division
Design Engineering Directorate

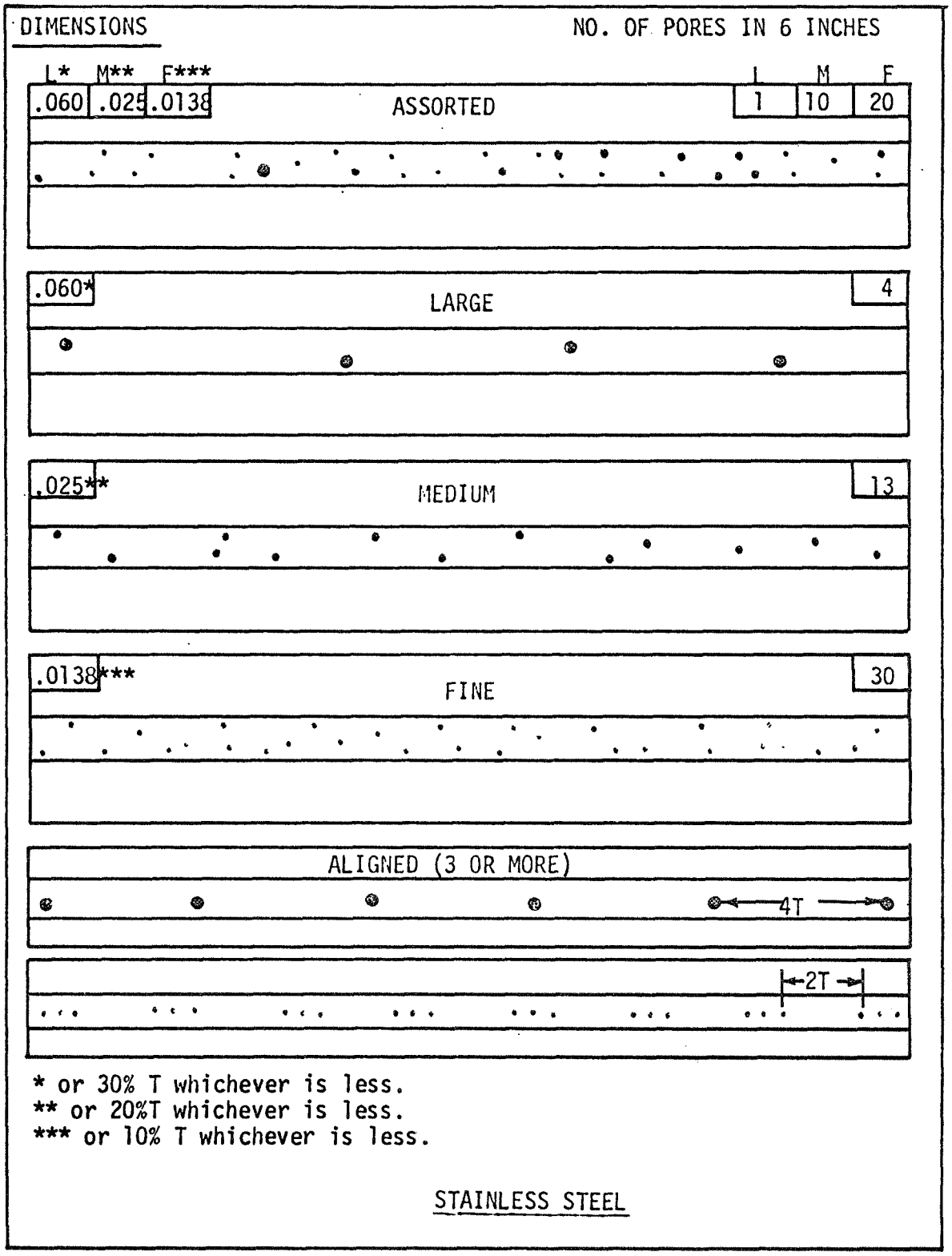


Figure 1. Maximum Permissible Porosity for Thickness of One-Quarter Inch or Less (Sheet 1 of 2)

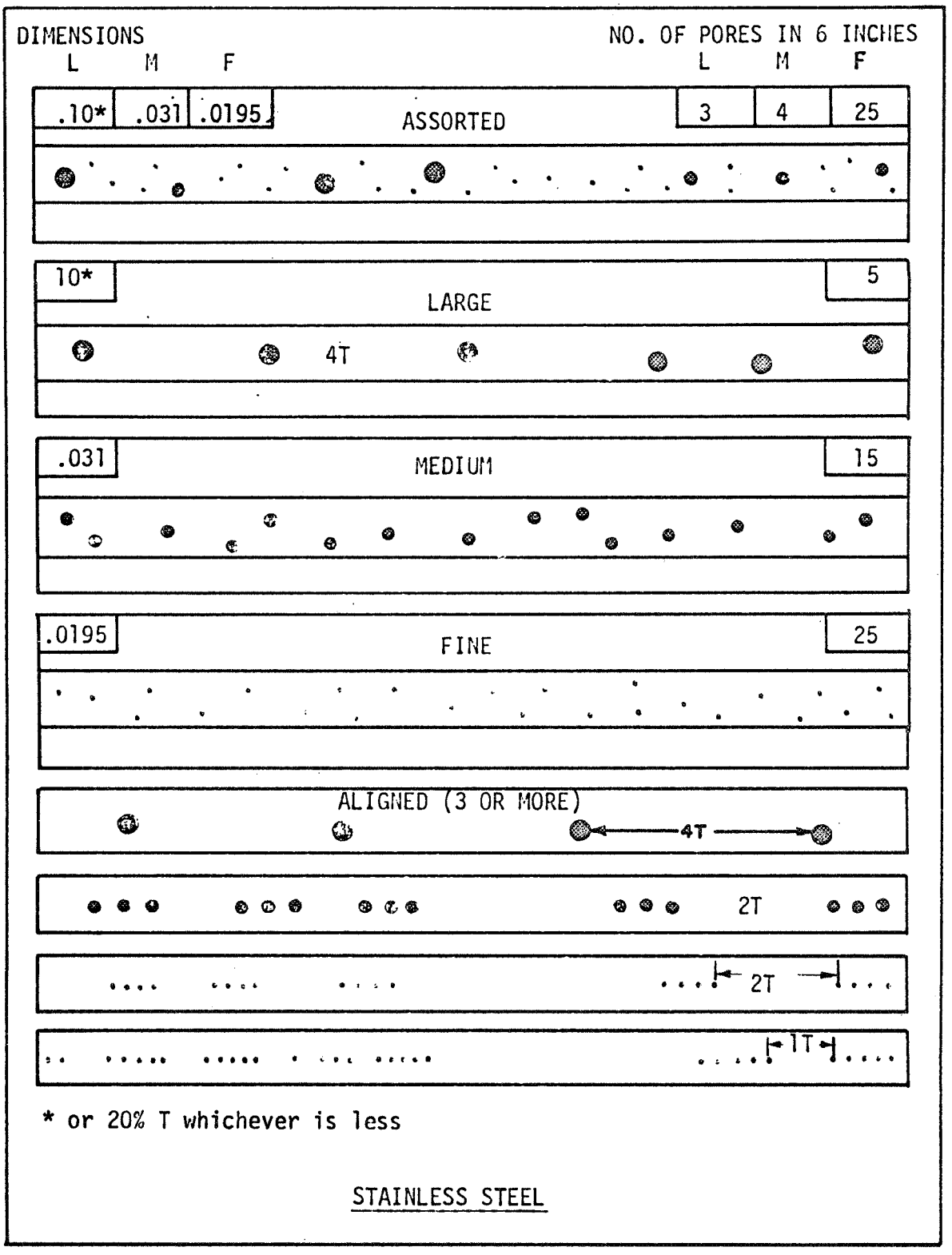
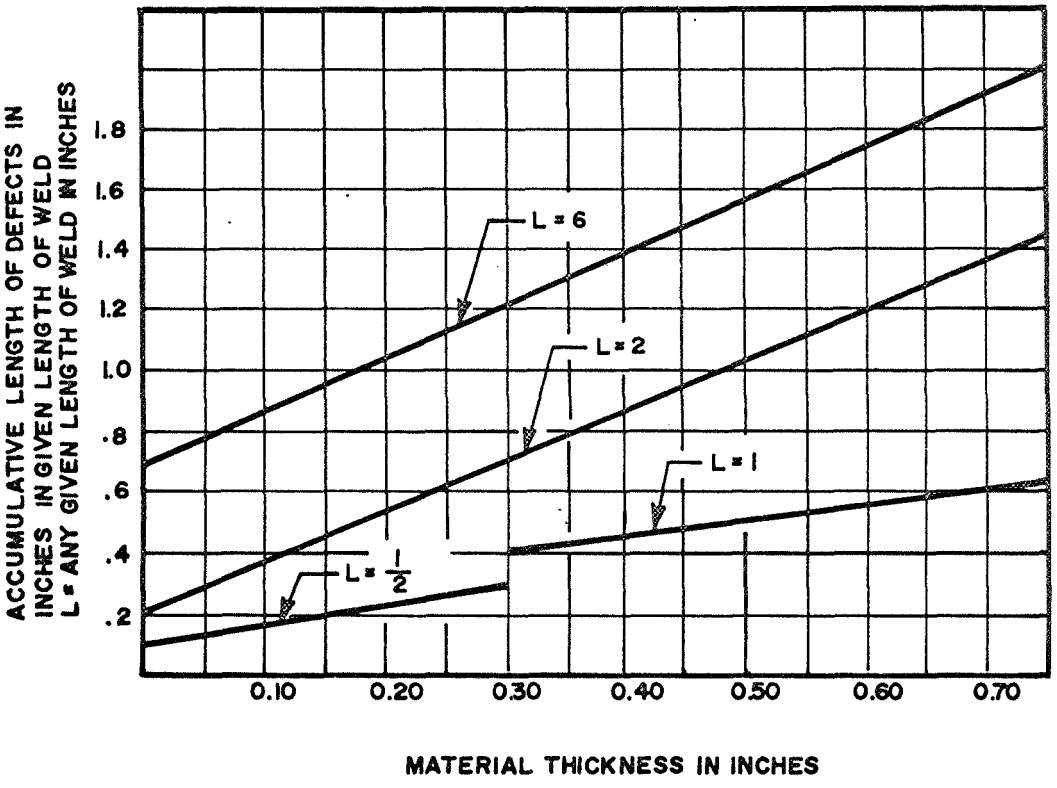


Figure 1. Maximum Permissible Porosity for Thickness of over One-Quarter Inch. (Sheet 2 of 2)



NOTE: Use worst case conditions.

ALUMINUM

Figure 2. Maximum Permissible Porosity

WELD INSPECTION RECORD

Weld Joint Identification_____ Detail Drawing No. _____

Shop Weld_____ Field Weld_____ Welding Procedure No. _____

Type of Joint:

Consumable Insert_____ Other _____

Type of Filler Metal_____ Type of Base Metal_____
(Attach chemical analysis) (Attach mill certification

Diameter of Pipe (Nominal)_____ Wall Thickness_____

Pressure of Pipeline (psi)_____

Joint Welder(s)_____

Fit-Up_____ Weld Setup_____

Interpass Temp._____

Radiography and Film Identification_____ QA_____

Penetrant Inspection_____ QA_____

Disposition of Weld_____ QA_____

Finish of Weld Appearance and Dimensions_____

Remarks:_____

_____

_____

Weld Certification:

By_____ Date_____
(Contractor's Inspector)

By_____ Date_____
(Government Inspector)

Figure 3. Sample Inspection Record Sheet for Pipe & Tubing Welds

Automatic Welding Procedure Specification No. _____

Date _____

(Title): AUTOMATIC WELDING PROCEDURE SPECIFICATION FOR.....

All work performed in accordance with this procedure shall meet the requirements of

Base Metal.- The base metal shall conform to.....(insert applicable specification or chemical analysis and mechanical properties as appropriate).

Filler Metal.- The filler metal shall conform to.....(insert applicable specification or chemistry, as appropriate).....and size shall be _____inch.

Inert Gas.- The shielding gas shall conform to.....(insert gas specification(s), chemistry, and gas mixture ratio if used) and torch flow rate shall be.....CFH. Purge rate shall be .....CHF.

Positions.- The welding shall be done in the .....(insert position(s) in which the welding will be done).

Heating.- (Describe any preheat, postheat, or temperature control during welding that will be done.)

Drying of Electrode.- (Describe the specifics of electrode drying).

Consumable Insert.- (Describe type of insert, if used.)

Base Metal Thickness.- This procedure is to be used to weld material thicknesses between _____and_____ inches.

Carriage Size.- Describe the applicable carriage to be used and denote range capabilities.

Preparation of Base Material.- Surfaces to be welded shall be cleaned immediately prior to welding for a minimum of 1 inch from the joint. Cleaned areas shall be free of all oil, grease, rust, scale or other impurities.

Joint Welding Procedure.- The attached sketch or sketches also show the joint design welding procedure, including tack welds, and includes the sizes for welding, filler metal, and electrode diameter, type of lineup clamps and when removed; type and timing of nondestructive tests, and the finished weld preparation.

Figure 4. Recommended Form for Automatic Welding Procedure Specification

W E L D I N G P R O C E D U R E D A T A S H E E T

DATE:

MATERIAL: INSERT SIZE: WELDING POSITION

SIZE: SHIELDING GAS FLOW RATE, C.F.H.

JOINT DESIGN: PURGING GAS FLOW RATE, C.F.H.

	PASS NO. 1		PASS NO. 2		PASSES _____	
	ACTUAL	DIAL SET	ACTUAL	DIAL SET	ACTUAL	DIAL SET
FILLER METAL TYPE						
FILLER METAL SIZE						
ELECTRODE TYPE						
ELECTRODE DIAMETER						
ELECTRODE EXTENSION						
STARTING POSITION						
LOWER CURRENT						
UPPER CURRENT						
TRAVEL SPEED SEC./REV.						
WIRE FEED SPEED I.P.M.						
TRAVEL DELAY SETTINGS,SECS.						
WELD CYCLE TIME, SECS.						
SLOPE SETTING SECS.						
SAFETY TIME SETTING,SECS.						
STEP CURRENT (AMPS)						
STEP TIME, SECS.						
ARC LENGTH						
AUTO. VOLTAGE CONT.						
OSCILLATOR SETTING						
PREHEAT TEMP. ^{O}F						
INTERPASS TEMP. ^{O}F						
PULSE FREQUENCY						

Test Results:

Radiographic Test Results _____ Ultimate

Tensile No.	Dimensions	Area	Pounds	PSI
A				
B				

Failed in: (Location) _____ QA _____

Guided Bend Tests

Root Bend	Result	Face Bend	Result
A		A	
B		B	

QA _____

Fillet Weld Test Results _____ QA _____

Figure 5. Recommended Format-Automatic Welding Procedure Qualification Test Record (Sheet 1 of 2)

Welder's Name _____ Clock No. _____ Stamp No. _____

Tests Conducted by _____ Lab. Test No. _____

We certify that the statements in this record are correct and that test welds were prepared, welded and tested in accordance with the requirements of

Signed _____ Title _____ Date _____

Figure 5. Recommended Format-Automatic Welding Procedure Qualification Test Record (Sheet 2 of 2)

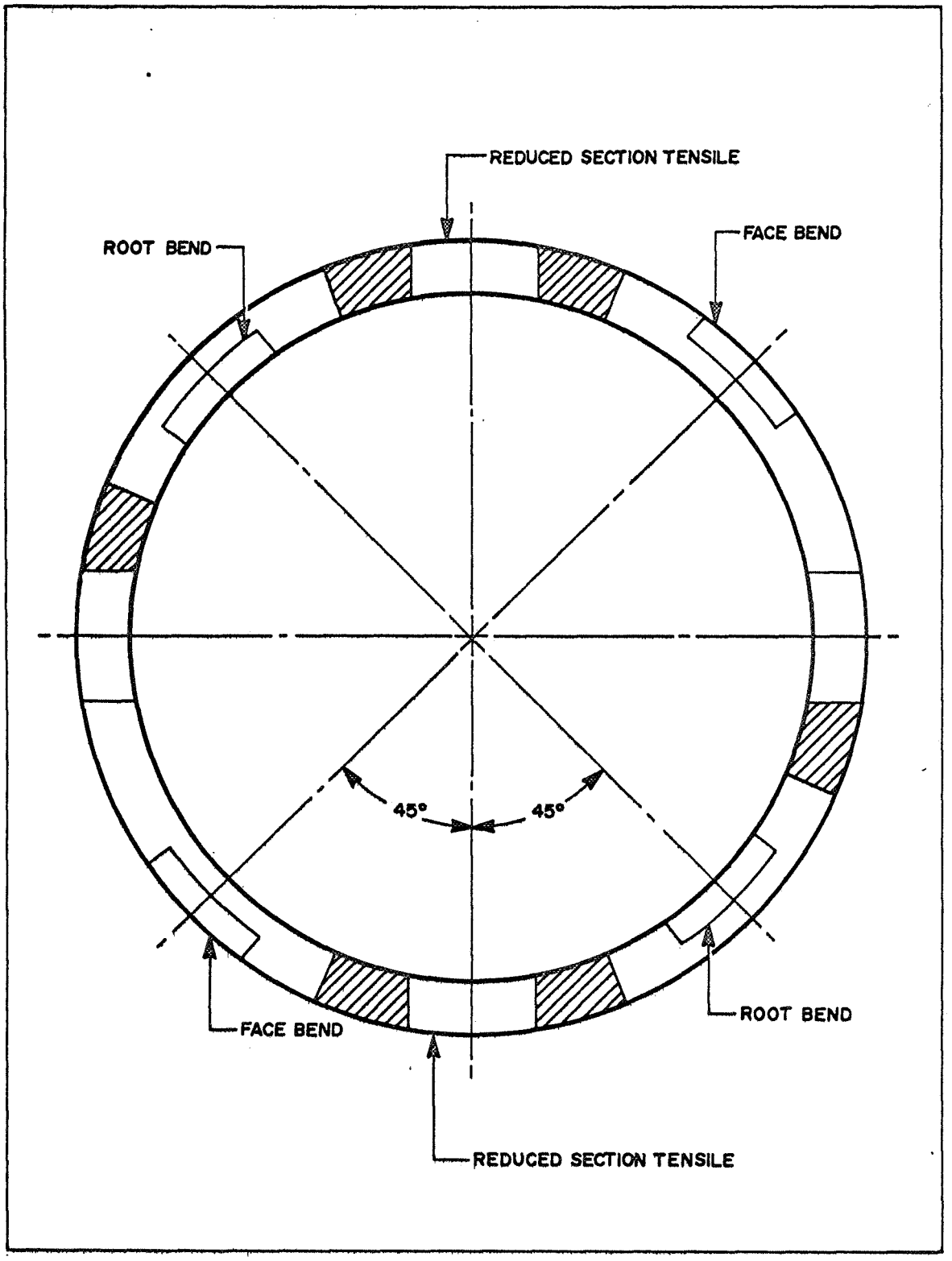


Figure 6. Location of Test Specimens (Pipe)

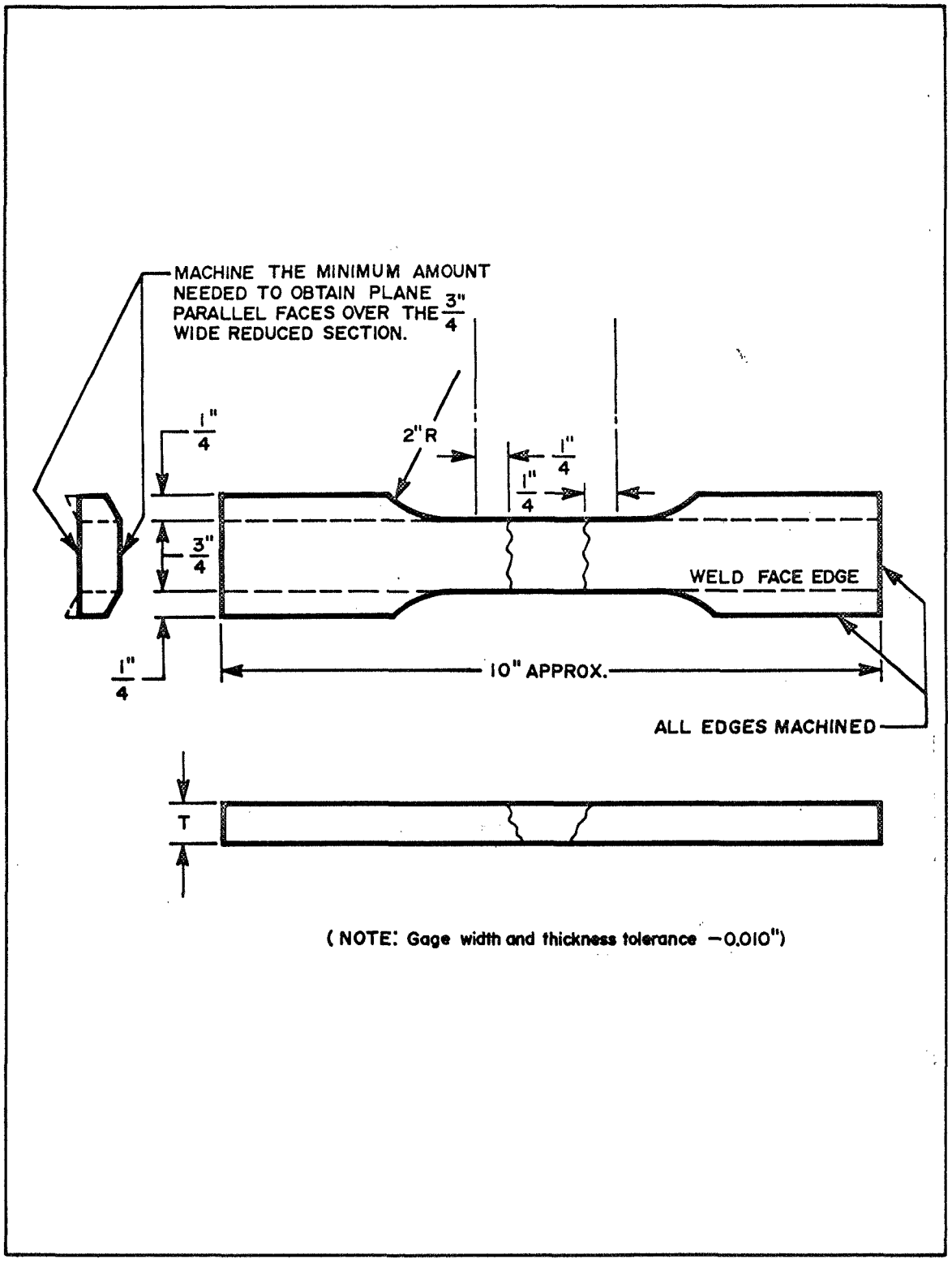
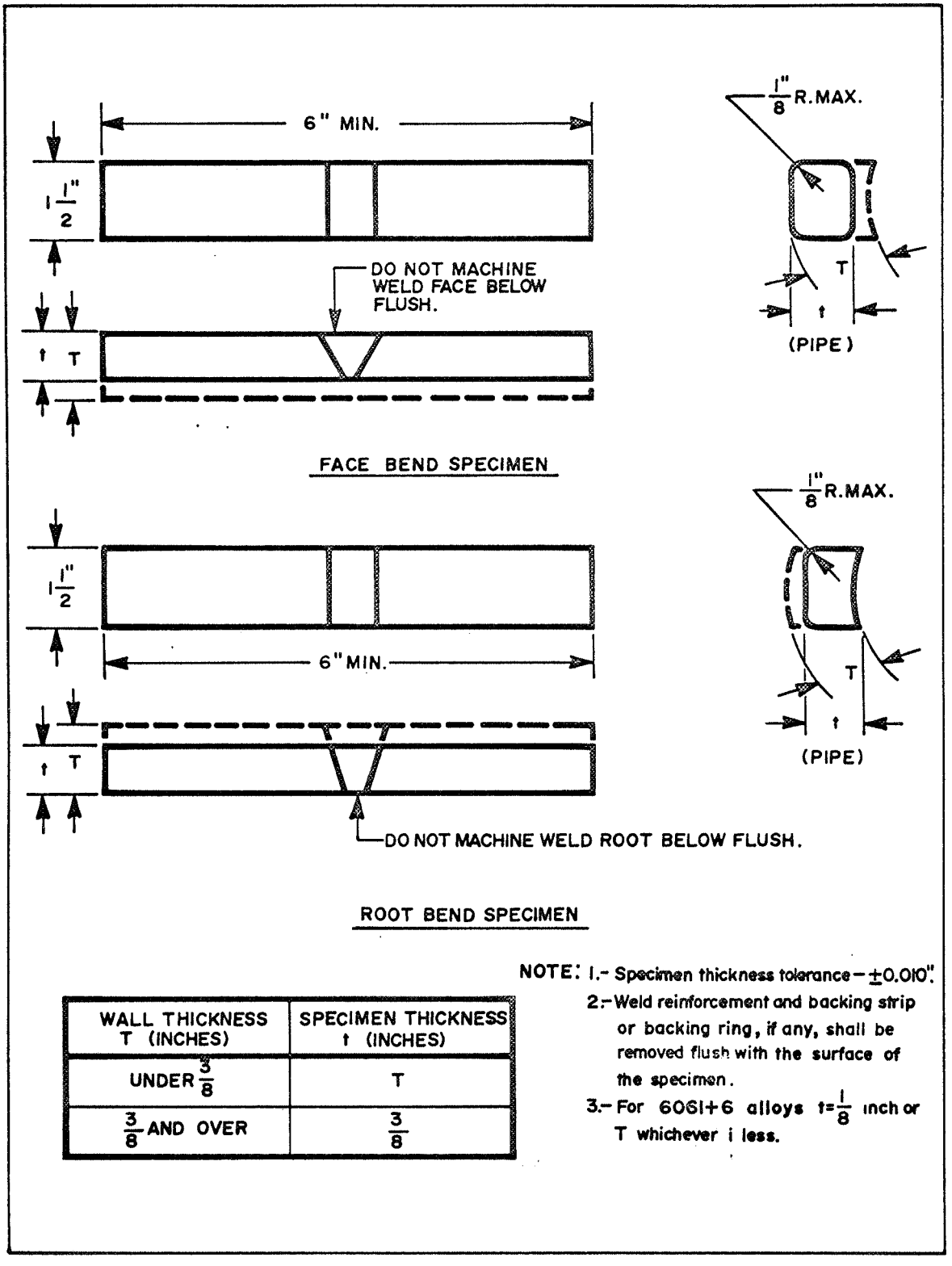


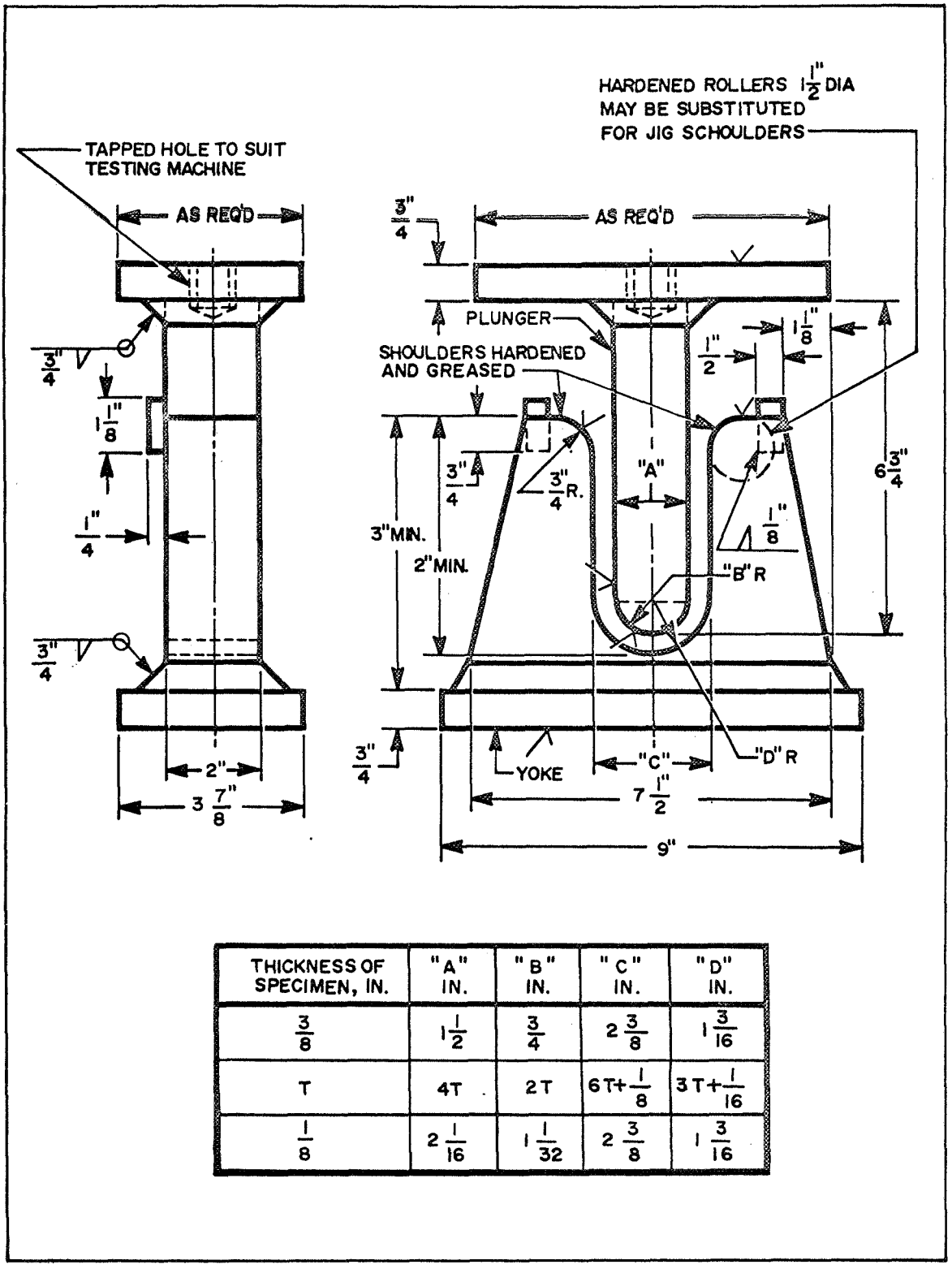
Figure 7. Reduced-Section Tensile Specimen



WALL THICKNESS T (INCHES)	SPECIMEN THICKNESS t (INCHES)
UNDER 3/8	T
3/8 AND OVER	3/8

NOTE: 1.- Specimen thickness tolerance – ±0.010".
2.- Weld reinforcement and backing strip or backing ring, if any, shall be removed flush with the surface of the specimen.
3.- For 6061+6 alloys t=1/8 inch or T whichever i less.

Figure 8. Transverse Face and Root Bend Specimens, Pipe



THICKNESS OF SPECIMEN, IN.	"A" IN.	"B" IN.	"C" IN.	"D" IN.
3/8	1 1/2	3/4	2 3/8	1 3/16
T	4T	2T	6T+1/8	3T+1/16
1/8	2 1/16	1 1/32	2 3/8	1 3/16

Figure 9. Guided-Bend Test Jig

1914

KSC-SPEC-Z-0016
2 June 1969

DISTRIBUTION LIST

John F. Kennedy Space Center, NASA
Kennedy Space Center, Florida 32899

A. Taylor, DE-RRO-2
J. Burke, DE-TEC
C. Wasileski, DE-CEM
D. Buchanan, DE-KEM
R. Dodd, DE-FAC
A. Zeiler, DE-MSD
J. Atkins, SF
J. Lacy, CC
R. Clark, TS
R. McDaris, QA
W. Lohse, AD-PRO
B. Driskill, AD-PRO-23
R. Hahn, DE-KEM-2 (4)
J. Gayle, SO-QUAL
G. Walter, DE-MSD-1
E. Davis, DE-MSD-2
W. Mims, DE-MSD-3
J. Campbell, SO-TSD-1
M. Harris, SO-FAC-3
M. Ballard, Catalytic/Dow
P. Karpa, Catalytic/Dow
A. Lietz, Catalytic/Dow
A. Hunt, BATC-1
W. VanDusen, Ben 3000
IS-CAS-42 (100 copies)

TOTAL: (127 copies)